Wisconsin Highway Research Program

Aesthetic Coatings for Bridge Components

Wisconsin Highway Research Program
LIMITED USE DOCUMENT

Department of Civil Engineering
University of Wisconsin-Milwaukee

March 3, 2010

Summary Page

Project Title: Aesthetic Coatings for Bridge Components

Proposing Agency: THE BOARD OF REGENT OF THE UNIV. OF WISCONSIN SYSTEM
UNIVERSITY OF WISCONSIN-MILWAUKEE
Graduate School - Research Services and Administration
Post Office Box 340
Milwaukee, Wisconsin 53201

Person Submitting the Proposal: Al Ghorbanpoor, Professor

Proposal Written By: Al Ghorbanpoor

Proposal Date: March 3, 2010

Principal Investigator: Al Ghorbanpoor
Co-Principal Investigator: Habib Tabatabai

Administrative Officer: Peggy Vanco
Graduate School - Research Services and Administration
Post Office Box 340
Milwaukee, Wisconsin 53201
pvanco@uwm.edu
414-229-4853

Proposed Contract Period: 24 months

Total Contract Amount: $120,000

Indirect Cost Portion at __15__%

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4. Research Plan

a. Background

i. Introduction and Review of the Available Literature

Various coating materials have been frequently used at, or subsequent to, the time of construction to enhance the appearance and durability of concrete and steel bridge members. As such, bridge owners have shown an increased interest in the use of these materials to enhance the aesthetics as well as the service life of bridge structures. Many of the current coating materials that are used primarily to enhance aesthetics are marketed as also being effective in providing protection of the bridge elements against hostile environmental conditions and other harmful influences. Such conditions may include exposure to ultraviolet radiation from the sun, moisture ingress, exposure to corrosive or other aggressive chemicals such as chloride ion, less than ideal substrate conditions such as in the cases of repaired areas where chloride ions or other aggressive chemicals could be present, wear and erosion, nicks and dents, severe thermal cycles, man-made damage or graffiti, and others.

Long term and effective performance of coating materials for aesthetics and durability of highway bridges may be achieved if certain requirements are fully taken into consideration and implementation. These requirements are associated with the material characteristics, design and construction aspects, geometrical details, surface preparation, installation, and future maintenance. Unsatisfactory performance of coating materials results when one or more of such requirements are not considered or implemented. Extensive research has been devoted to the performance of coating materials under various service conditions for bridge structures. A broad conclusion from the past research supports the notion that a proper material selection for a specific application along with following the correct surface preparation and application procedure could result in long term satisfactory performance of coating materials in bridges.

One of the first comprehensive research studies to evaluate the performance of various concrete coating materials was performed by Pfeifer and Scali in 1981 (Ref. 1). This study evaluated the durability performance of 21 coating materials for non-deck applications in bridges. While the study found high variations in the performance within generic classes of the materials tested, it was able to establish good to excellent performance records for certain formulation among the tested materials. Other NCHRP research reports indicated a relatively more widespread use of the low-viscosity thin-film sealers but also noted a distinct variability in the durability performance within generic groups (Ref. 2, 3). A more recent research study by Zemajtis and Weyers has shown that certain classes of concrete sealers can enhance the service life of concrete structures in aggressive corrosive environments (Ref. 4). An Illinois DOT research report published in October 2009, presents performance and durability data based on a seven year test program for 21 coating materials as well as information on a developed protocol for selection and evaluation of coating materials for bridge deck applications (Ref. 10). The study showed that by considering both the effectiveness and cost, it was possible to develop a recommended policy for the use of bridge deck sealers and laminates for preventative maintenance in Illinois bridges.

As a part of a recent WHRP sponsored research study conducted by the proposed principal investigators, a comprehensive review of various protective coating materials for concrete was completed. The results of that study showed a significant enhancement of the durability performance of concrete structures subjected to corrosive exposures when certain coating materials were applied (Ref. 6). Accordingly, WisDOT now requires that the ends of all new prestressed bridge girders be coated using certain epoxy-based coating materials to prevent local deterioration due to exposures to aggressive chemicals. A recently published article by

Kogler has summarized the research approaches and results from a number of recent studies, including this work, as related to the application of coating materials in concrete bridge structures (Ref. 7).

The Paint and Corrosion Laboratory (PCL) at FHWA's Turner-Fairbank Highway Research Center is an additional source of information for coating materials that are used for corrosion protection of structural steel in bridges. As a part of its activities, the PCL conducts tests on various structural steel coating materials as well as assisting state DOTs to identify appropriate coating materials for different environmental conditions.

Since the early 2000's, an important source of information and standardization for coatings that are used for corrosion protection of structural steel in bridges has been the National Transportation Products Evaluation (NTPEP) program that operates under the AASHTO's oversight. The Structural Steel Coating Systems (SSC) Committee of the NTPEP, consists of representatives from various state DOTs and other experts that facilitate standardization of various coating materials under a model of "national testing." Coating manufacturers can choose to have their products certified by approved organizations through laboratory and field testing. The results of such testing and evaluation is made available to various state DOTs for future use of the tested products. The SSC is now considering the changing of its name to "Protective Coating" committee to reflect its consideration of other products such as concrete coating materials, galvanization, thermal sprays, metalizing, and others. Over the last several years it has become clear that a similar protocol will need to be developed so coating materials for concrete can be effectively evaluated and pre-qualified. With that objective in mind, currently a subcommittee of the SSC from NTPEP in collaboration with AASHTO, and other experts, is working to develop a protocol for concrete coating materials. The research staff for this proposed study is actively involved in that effort and as a member of the subcommittee. In this work, the existing protocol for coating of steel materials is used as a baseline and appropriate modifications are introduced to account for concrete with respect to differences in its surface conditions, various modes of deterioration, and material characteristics. A draft report has recently been produced that addresses various test methods that will be required to pre-qualify such coating materials. This year, the draft protocol is expected to be distributed among the full SSC membership as well as AASHTO members for further consideration and balloting.

The most recent and relevant source of information to this proposed research is a 2006 study by Palle and Hopwood (Ref. 5). This study was performed at the University of Kentucky Transportation Center (UKTC), and evaluated nine coating materials by different manufacturers against control samples with no coating application. These coating materials were determined to be commonly used in several states to enhance both the aesthetics and durability of bridge structures. The study subjected these coating materials to several standardized ASTM-based laboratory and field tests to determine their effectiveness in resisting environmental factors (color variation due to weathering), penetration of chloride ions, adhesion strength, and water vapor transmission rate. The study identified some of the coating materials with superior performance based on those tests. The research staff at the UKTC has been monitoring several coated samples in the field for longer term performance over the last few years (Ref. 8).

It is possible to achieve a relatively long life for coating materials if appropriate conventional materials, including galvanization, are selected and correct application procedures are followed. It has been shown that more advanced coating applications such as organic and inorganic zinc rich coating materials can significantly enhance the corrosion resistance of steel bridge components for over 50 years (Ref. 9). While the cost of such coating material may be 30% to 50% higher than that for conventional materials, there is a clear long-term performance benefit as well as an actually lower life cycle cost. In particular, if it is required to remove the existing paint, then the initial cost difference for using the higher quality zinc rich material will be within only a few percentage points.

Wisconsin DOT maintains updated lists of selected pre-qualified/pre-approved coating materials and systems from different manufacturers for steel and concrete structures (Ref.11). This information is used by design engineers and contractors to provide the state with products that meet the required specifications for performance and durability. The current WisDOT product lists most relevant to the scope of this research study include:

- Concrete Protective Surface Treatment (sealers)
- Low Viscosity Crack Sealers for Bridge Decks (sealers)
- Cure & Seal Compounds for Non-Trafficked Surfaces on Structural Masonry (stains, sealers, coloring)
- Paint Systems- New Structural Steel (2- & 3-coat systems for steel)
- Paint Systems - Structure Maintenance Painting (steel cleaning & repainting)
- Rapid Set Concrete Patch (repaired substrate for coating)
- Solventborne Paints (for pavement marking)
- Waterborne Paints (for pavement marking)

A review of the WisDOT's pre-qualified product lists, indicates that they reflect the national trend where a better and more effective pre-qualification criteria exists for steel structures than concrete. This applies to both new structures as well as maintenance related applications. Clearly, the WisDOT's product lists can be enhanced if this study is successful in developing a practical guideline as well as an effective protocol to pre-qualify various coating materials for both steel and concrete applications.

There are several ASTM and AASHTO test standards that pertain to the evaluation of coating materials subjected to environments similar to those for bridge structures. A comprehensive list of relevant ASTM and AASHTO standards for coating materials in bridges is presented in Appendix A of this proposal. The list includes test and application standards for coating materials applied to both steel and concrete substrate. An appropriate number of test standards from this list will need to be identified and followed during this study to establish minimum criteria for acceptance and application of coating materials that will be used for Wisconsin bridges.

ii. Statement of Problem

Bridge owners make significant investment to utilize coating materials to enhance the aesthetic and durability of concrete and steel bridge structures. As such, they expect reasonably good quality and performance over a relatively long service life of such structures. Unfortunately, it has been the experience in Wisconsin and elsewhere that not all coating materials in the market perform well and as advertised in real applications. These failures have generally been in the form of fading colors, peeling, blistering, rust bleeding, staining, low resistance to man-made damage such as graffiti, incompatibility during repair work, and ineffectiveness as surface barriers to prevent penetration of moisture and aggressive chemicals into concrete or steel substrate that result in corrosion and rust stain. The primary causes of such material failures are ineffective surface preparation prior to the application of coating materials and exposure to severe service conditions during the life of bridge structures. Other causes such as poor geometric details and faulty application can also contribute to premature failure of coating materials. In addition, chemical and mechanical properties of coating materials may degrade over time due to various factors. Such material degradation includes strength reduction in the film, increased brittleness (causing cracking), increased internal stresses (causing peeling), increased porosity, loss of resin, de-bonding from substrate, and others. Accordingly, bridge owners are faced with undesirable appearances at bridge sites and are concerned about the durability of such structures. This has introduced an ongoing problem of making costly repair without being able to fully restore the aesthetic and durability performance of bridges as well as higher life cycle cost.

Wisconsin Regional DOT maintenance staff have experienced frequent failures of coating materials applied to various bridge components. Due to the types of environments and usage, some state DOT regions have had more cases of coating failures than others. Sometimes, the coating failures occurred within only a few months of the initial coating application even on new structures. An example of this premature failure is the peeling of the coating material at the Marquette Interchange bridges in Milwaukee, according to John Bolka, Regional Structures Maintenance Engineer, for the WisDOT SE-Waukesha Office. Another example is the coating (stain) failure by peeling at the Lake Parkway bridges and sound barrier walls in Milwaukee when it occurred after only one year. The cause of this premature failure was associated with a faulty initial surface preparation and the presence of formwork release agents at the surface of concrete that was not sufficiently removed prior to the application of the coating material. The peeling failure of paint on concrete surfaces can sometimes be due to a chemical reaction (saponification) between the oil in the paint and alkali in the concrete causing the appearance of a white film, flaking and blistering of the paint. It may be necessary to neutralize the alkali condition at the concrete surface through an appropriate chemical treatment prior to application of the coating material so adequate bonding can take place.

Similar coating problems have been observed in several Midwestern and other states. For example, over a 20-year period from the early 1980's, Ohio DOT used epoxy–based paints to coat their concrete bridge members. They experienced various problems with the lack of water vapor transmission (breathability) and UV stability issues that eventually lead to the failure of such coatings. Later, Ohio DOT started the use of epoxy-urethane coating systems. Although better performance was experienced with the new system, the DOT had to deal with problems associated with the mixing and application of this material. Michigan DOT has had good performance experience with the use of acrylic concrete coatings for aesthetics and protection but has had issues of concerns about the use of appropriate curing compounds, surface preparation, and cold temperature applications. Indiana DOT has been using Polyurea based coating systems for their concrete highway structures but has experienced performance problems particularly in friction members such as driving and walking surfaces. California DOT has also used polyurea coating systems for their concrete structures. The main source of concern in California has been cases of UV failures and requirements of surface preparation for maintenance painting where cracks and "bugholes" must be filled prior to the application of the coating materials.

It is a general belief that there is a major problem with the use of coating materials for highway applications and that several factors contribute to the observed cases of failure. These factors primarily include ineffective initial surface preparation, poor structural details that facilitate standing water and aggressive chemicals to be accumulated on coated surfaces, improper applications, poor material characteristics, and hostile environmental conditions. It is also possible that the residual release agents from concrete molds may hamper the proper surface preparations.

From the above discussion, it is clear that WisDOT can benefit from a comprehensive study that can evaluate the effectiveness of available coating materials for Wisconsin highway applications, and establish specifications and guidelines for effective future selection and use of such materials.

iii. Objectives

The primary objectives of this study are to:

- Review the current practice and experience with the use of highway related coating materials in Wisconsin, other states, and abroad,
- Identify appropriate coating materials that can enhance the aesthetics and durability of concrete and steel bridge components over a long period of service,
- Conduct laboratory and field tests to verify long term performance and quality of the selected materials,
- Develop guidelines and specifications language for appropriate selection, application, and maintenance of such coating materials, and
- Make recommendations for the implementation of the results of this study.

iv. Benefits

The completion of this study will result in a scientifically-based rating system that allows for reliable and effective identification, selection, evaluation, and application of appropriate coating materials for concrete bridge members and steel railings. Guidelines and minimum acceptance criteria will be developed as a part of this study that will aid the Wisconsin DOT to achieve long term satisfactory performance from coating materials that will be used in Wisconsin bridges. The research team will collaborate with appropriate Wisconsin DOT personnel to develop a draft policy based on life-cycle cost for statewide use of coating materials. The outcome of this study will help the Wisconsin DOT to use its bridge construction and maintenance funds more efficiently.

b. Research Approach

i. Work Plan

The objectives of this study will be achieved through performing the following tasks:

Task 1. Review of Current Practice and Available Literature

The research team will conduct a comprehensive review of the available domestic and international literature concerning standards, guidelines, materials, preparation, application, structural details, and long term performance of various coating materials for highway bridges and similar applications. Standards and available test data from the Structural Steel Coating (SSC) System of the NTPEP will be obtained for further evaluation. Relevant publications of the Federal Highway Administration through its Paint and Corrosion Laboratory will be obtained and reviewed. On-line sources of information as well as conventional search databases will be utilized. Various technical online data bases (journals, etc.) through UW libraries as well as the interlibrary loan service, can give access to literally any source throughout the world within a reasonable time. The PI is a working member of a RILEM technical committee on concrete structures. In that capacity, he interacts with European colleagues concerning concrete structures and materials. The relevant European experiences will be incorporated into this study. In particular, the Canadian experience will be reviewed and considered as it offers similar or more severe environmental conditions compared to Wisconsin.

The research team will collect, review, and classify the available literature including product data for coating materials that have been used or have the potential for future use in bridges by WisDOT and other states. This will serve as a data base that can help identify more appropriate and effective coating materials that could be used in the subsequent tasks of this study. The principal investigators for this proposed study recently completed a WHRP study that evaluated the performance of various sealers to protect prestressed concrete bridge girders against hostile environmental conditions (Ref. 6). As a part of that study, a comprehensive review of literature was performed that could be beneficial to this proposed research.

At the completion of the literature review task, a summary report will be prepared and submitted as a part of the interim report (Task 3). The report will include information regarding available standards, guidelines, materials characteristics, performance and life expectancy of various coatings under different environmental conditions.   An emphasis will be placed on the inclusion of information that will have an impact on the development of practical and reliable material acceptance criteria and rating system.

Task 2. Survey of WisDOT, Other States, Contractors and Manufacturers

The research staff will conduct a formal survey of WisDOT staff from different regional offices, other states, FHWA staff, consultants, contractors and manufacturers to document the current coating practices and experiences. The survey/questionnaire will include various parameters including results of relevant studies and reports, types of organic and inorganic coating materials that are used for new and maintenance applications (including anti-graffiti coating), existing standards, performance records, product specific data, minimum acceptance criteria, pre-qualified materials lists, guidelines, environmental conditions, exposure types, geometrical details of base materials, material selection process, aesthetics performance, protection and durability (permeability) performance, material characteristics, surface preparation requirements, application processes, quality control requirements and procedures at various stages, maintenance provided, types of failures observed, premature failure case studies, and causes of failure. Comments and suggestions from the project oversight committee as well as the consulting collaborators for this study will be sought to enhance and finalize the survey document prior to its distribution.

Mr. Theodore Hopwood of the University of Kentucky Transportation Center serves as a consultant to this study – a letter of collaboration is attached to this proposal. He was the principal investigator for a similar recent study (2006) in Kentucky that established performance criteria for a number of coating materials that are used by several Midwestern states to enhance the aesthetics and durability of concrete and steel bridges. As a part of the KY study, a survey of several state DOTs and coating manufacturers was conducted to identify common materials, practices and experiences related to coating materials used in steel and concrete elements of bridge structures. The research staff for this proposed study will expand the results of that survey by obtaining updated information from the previous responders as well as collecting new information from other states, consultants, and manufacturers.

Mr. Robert Kogler, president of Rampart, LLC, also serves as a consultant to this study - a letter of collaboration is attached to this proposal. Rampart, LLC is a consulting firm that provides technical and management related solutions to owners of infrastructures. Until recently, and for over ten years, he served as the manager of the corrosion and bridge durability research program for the Federal Highway Administration, the Turner-Fairbank Highway Research Center.   In that capacity, Mr. Kogler has a long history of working with various staff at all U.S. state DOTs who are responsible for bridge coating and protection as well as numerous contractors and manufacturers. Mr. Kogler, through his broad technical contacts, will be an invaluable asset to assist the research team to conduct a successful survey of coating materials and experience in other states. Mr. Kogler is an active member of the NTPEP's SSC subcommittee that is charged with the development of a national testing protocol to pre-qualify coating materials for concrete bridges. His knowledge and experience from this work will be invaluable to the success of this proposed study.

The results of the survey from Task 2 will be evaluated to determine what studies would be necessary as a part of this proposed study to achieve long-term satisfactory performances for coating materials used in highway applications in Wisconsin. Based on the documented survey information, a list of promising coating materials will be prepared that will be considered for further testing and evaluation in the subsequent laboratory and field studies of this proposed research (Task 4).

Task 3. Interim Report

The research staff for this study will prepare an interim report that will summarize the findings from Tasks 1 and 2. Based on the findings from Tasks 1 and 2, the interim report will include a revised work plan for Task 4 to perform laboratory testing and field evaluation of existing structural details during Task 4 of the study. As a part of the revised plan, a selected group of coating materials for steel and concrete applications will be recommended to the project oversight committee for approval and testing in Task 4. A detailed test program for Task 4 will also be recommended for approval. The recommended test program will include details of all specific tests and relevant ASTM standards as well as expected results. The test results will serve as one of the primary elements for pre-qualifying coating materials and as an aid to develop appropriate selection and application guidelines and standards.

The revised work plan will also include a program of collaboration with various WisDOT regional maintenance engineers to review different structural details in bridges and highways that have exhibited acceptable as well as unacceptable coating performances. Based on that review, appropriate field visits will be proposed to inspect and document such coating performances.

Task 4. Laboratory Testing and Field Visits

As shown earlier in this proposal, a large number of ASTM and AASHTO test standards address the use of various coating materials for steel and concrete substrates. The research staff has identified a subset of such standards as the most appropriate for the objectives of this study. At this time, these suggested standards include ASTM E96, ASTM E308, ASTM D610, ASTM D714, ASTM D1654, ASTM D4541, ASTM D5894, AASHTO T259 and AASHTO T260. Additional test standards may be appropriate for this study. A final list will be determined in consultation with the project oversight committee during the Task 3 submission of the interim report. It is envisioned that the results achieved under this task of the study will be a primary element for coating materials performance evaluation and it can aid in establishing appropriate criteria for minimum qualification and material selection.

Overall performance of coating materials for both steel and concrete applications generally depends on material characteristics, application processes (i.e, proper material handling and mixing, geometrical details, surface preparation, substrate conditions, repaired surfaces, etc.), and environmental exposures. Accordingly, these general parameters must be closely defined and implemented in an effective and practical way to perform a meaningful accelerated laboratory testing program. In order to achieve useful results, the test program must closely simulate the real field conditions and service life of the bridge members. Accordingly, the proposed work under this task is presented in a format to consider and implement these general parameters.

1. <u>Coating Material characteristics:</u>

For all selected coating materials, relevant manufacturers' specifications and technical data will be collected and reviewed. Chemical analysis tests will be performed in our Advanced Analysis Facility (AAF) Laboratory to verify manufacturers' reported material data. The laboratory is equipped with advanced chemical analysis instrumentation, including mass spectrometer, Fourier transform infrared spectrometer, UV spectrophotometer, scanning electron microscope, atomic transmission microscope, optical microscopes, and equipment for trace components analysis (e.g., gas chromatograph-MS, ion chromatograph-AES). The focus will be placed on the generic classification of materials to avoid the necessity for disclosure of information for proprietary information by the manufacturers.

2. Application Processes:

All selected coating materials will be handled, stored, and applied according to the manufacturers' recommendations. These materials will be classified into new applications as well as maintenance or repair applications. For new applications, surface preparation of the test samples will be done according to the manufacturers' recommendation. For maintenance applications, the manufacturer's recommendation will be followed but the test samples will be modified to have realistic characteristics of repaired components in the field. Accordingly, these test samples will first be subjected to accelerated weathering conditions and the coating materials will be applied later after making any required repair of the test samples using approved patching materials. The repaired and coated samples will then be subjected to environmental conditions again to evaluate the performance of the coating materials under maintenance conditions.

3. Environmental Exposures:

Some of the most important characteristics of coating materials are their resistance to weathering and UV exposures and being suitable for use in repair cases where chloride ion, other aggressive chemicals, and less than ideal surfaces are present in the substrate. In environments similar to that in Wisconsin, the weathering exposure includes cyclic introduction of wet and dry conditions with the presence of a high concentration of chloride ions. In addition, the weathering conditions include exposure to the UV radiations from the sun. It is known that exposure to the UV radiations can introduce a significant detrimental effect to the appearance and long-term satisfactory performance of most coating materials. For the last several years, the most acceptable accelerated laboratory testing to consider the effects of weathering and UV radiations has been based on the standard identified as ASTM D5894–05: Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal. Although the test standard is developed for application to metals, a slightly modified procedure can be used for concrete applications. This standard has been accepted by the AASHTO and NTPEP.

Testing under ASTM D5894 requirements are tedious and expensive (i.e, the commercial cost rate is in excess of $20 k per each coating system) but will offer the best estimate of the expected long-term performance of coating materials for weathering and UV exposures. The test method includes weekly cyclic exposures of 3"x 6"or 4" x 12" coated samples (panels) to UV (weathering) plus salt fog spray (corrosion) in controlled QUV and fog salt spray (prohesion) chambers with automated controls. Five samples will be used for each coating system to improve the statistical representation of the test results. The UV exposure consists of alternating one-hour condensation and one-hour of UVA light exposure for one week (168 hours). The salt spray exposure (prohesion) includes alternating spray with a solution of sodium chloride and ammonium sulphate at ambient temperature followed by one-hour of evaporation drying at 95 ^{o}F for one week (168 hours). The test is required to run for 30 weeks or 5040 hours. Accordingly, test samples are alternately subjected to approximately 2500 hours of exposure to UV radiations and 2500 hours of exposure to salt fog spray. Every six weeks, the samples will be photographed and evaluated for color and surface appearance variations according to ASTM E308. At the conclusion of the test, all samples are evaluated for evidence of blistering (ASTM D714), rusting (ASTM D610), undercutting (ASTM D1654), pull-off strength or peeling (ASTM D4541), and color retention (ASTM E308). An additional set of coated concrete samples (panels) will be subjected only to the UV exposure tests (2500 hours) to determine the effect of salt fog spray on the performance of the coating materials. All of the above tests will be performed in the QUV and prohesion chambers of the UWM Structural Engineering Laboratory. Additional tests will be required for coated concrete samples to determine their resistance to chloride ion penetration (AASHTO T-259 & T-260). Three coated concrete test samples will be made for each coating system. Each sample will be 12” x 12” x 6” thick. The samples will be subjected to weekly wet/dry cycles of 3% sodium chloride solution for 9 months. At the conclusion of this period, chloride ion penetration in the concrete will be measured at the depths 0.25”, 0.5”, and 1.0” from the surface. Three test locations will be used for each sample. Additional coated steel and concrete samples will be prepared for measuring the pull-off capacity (adhesion) of the coating materials according to ASTM D4541. The steel sample will be similar to those for the QUV/prohesion tests. The concrete samples will be in the form of 3-in solid cylinders that will be sectioned into halves and coated according to the requirements of the test standard. All steel and concrete samples for the pull-off tests will be subjected to the QUV and prohesion tests and a *Patti* tester device will be used to determine the adhesion strength of the coating materials after the exposure test period. Three samples will be prepared and tested for each coating system.

It is envisioned that a total of 10 different coating systems will be selected for final evaluation under this study. At this time, the assumption of the research staff is that the selection will include 2 systems for new steel, 1 system for maintenance steel, 5 systems for new concrete, and 2 systems for maintenance concrete applications. The final distribution will be decided in consultation with the project oversight panel during the task 3 of the study. Accordingly, the following matrix of tests will be performed to satisfy the requirements of this task of the study.

Coating Systems Substrate	# of Coating Material Systems	# of Samples for QUV+Prohesion Tests (3”x6” or 4’x12”)	# of Samples for QUV Tests (3”x6” or 4’x12”)	# of Samples for Chloride Penetration Tests (12”x12”x6”)	# of Samples for Chloride Ion Tests	# of Samples for Pull-Off Tests
Steel (new)	2	10				6
Steel (maintenance)	1	5				3
Concrete (new)	5	25	25	15	45	15
Concrete (maintenance)	2	10	10	6	18	6

During this task of the study, the research staff will work with appropriate WisDOT staff from various regions to review and document problems with coating failures for steel and concrete structural details. Contract documents, shop drawings, current standards of practice, and maintenance records will be reviewed to obtain an in-depth understanding of the problems and their relevance to the types of geometrical details and field conditions. In collaboration with the WisDOT staff, a minimum of 5 sites will be identified and visited to examine and document the corresponding field effects and problem contributing elements.

The research staff will also review various factors that contribute to the cost of using coating materials in highway applications. These cost parameters will include the cost of material, surface preparation, application, frequency of required maintenance and repainting. The cost information will be determined by obtaining cost data from manufacturers, and contractors. Accordingly, a cost analysis will be performed that will be based on the initial cost and a life cycle cost during the expected life of the structure.

Task 5. Identify Future Research Needs

Based on the results and findings of this study, the research staff will prepare and present a discussion on the future research needs related to better utilization of coating materials in highway applications.

Task 6. Develop Guidelines and Provisions for Materials Selection and Application

One of the primary objectives of this study is to develop appropriate guidelines and special provisions for coating materials selection and application. As indicated under task 3, this effort will be based on using a set of selected coating systems for both concrete and steel after they are approved by the project oversight committee (POC). The coating systems will be proposed to the POC based on various aspects including material type, surface preparation, application, durability, repair cases, protection of underlying material, graffiti resistance, and cost. For steel railings, the guidelines and provisions will include structural details to help prevent rust bleeding. The structural details will include requirements for appropriate drain, vent and bolt holes, fabrication, field erection, expansion joints, and member properties to avoid warping during hot dip galvanizing. The research team will obtain from WisDOT and review existing special provisions and structural details and make recommendations to update the Wisconsin Bridge Manual, special provisions, and standard drawings. Also, according to the results of the proposed testing program, the research team will develop and recommend an approved products list for WisDOT.

These guidelines and provisions include information to assist bridge owners to select appropriate coating materials for specific applications within the environmental parameters as related to highway structures in Wisconsin.

Task 7. Draft Final Report

A draft final report will be prepared and submitted 3 months prior to the end date of this study. The draft report will include the results of the literature review, the outcome of the survey of materials, practices, and experiences in Wisconsin and other states, the details and results of the experimental program, results of the review and field investigations of Wisconsin standards and structural details as related to the performance of coating materials, comparison of the results and findings with other sources of information including those from AASHTO and NTPEP, and the completed guidelines and provisions for materials selection and application.

Task 8. Final Report

The research staff will incorporate the comments and suggestions from the project oversight panel, the WHRP Structures Task Oversight Committee, and other appropriate experts into the final report and will submit it prior to the end date of the contract.

ii. Expected Contribution from the WisDOT Staff

The research team will seek WisDOT staff's assistance to identify and make available sources of information for structural details related to coating applications and performance for concrete and steel components in bridges. In addition, assistance will be sought for identifying and providing access to appropriate bridge sites with good performance records as well as those that have experienced various types of failures of coating materials. These or other bridge sites may be used for installation of a selected number of promising coating materials for future studies and evaluations.

c. Anticipated Research Results and Implementation Plan

The results of this study will be summarized and presented by the PI at one or more meetings of the WHRP's Structures TOC. In addition, an implementation plan will be developed and submitted to WHRP at the time of the submission of the final report. The implementation plan will include a brief summary of the results of the study and guidelines for selection and application of coating materials for both new and maintenance (repair) purposes. The summary will be prepared in the form of a brochure that can be distributed and utilized more effectively.

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11. Wisconsin DOT Approved Lists (Pre-Qualified Product List) http://www.dot.wisconsin.gov/business/engrserv/docs/ap0/approved-lists.pdf

5. **Time Requirement/Schedule**

It is anticipated that the starting date for this study will be October 1 2010 and the project duration will be 2 years. A Gant chart and the committed hours by task for the research staff are shown below.

	Time (Quarters)							
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	XXX	XX						
2	XX	XX						
3	X	XX	XX					
4			X	XXX	XXX	XXX	XX	
5						XXX		
6						XXX		
7						XXX	XXX	
8								XXX